REMARKS

The Examiner is thanked for the thorough examination and search of the subject patent application.

All claims are believed to be in condition for Allowance and that is so requested.

Aluminum caps are known and are used over, and to protect, contact points, and specifically, IC-copper metal bond pads on semiconductor wafers, the protection being needed during shipment of the wafers to be packaged (since copper is corrosive in the open environment). The Aluminum caps over the IC copper metal bond pads are also used to be wirebonded to, as it is well known in the art to wirebond to aluminum (since copper pads are not suitable for being wirebonded by gold wires). The copper is used for the interconnect metallization including the bond pad, and then an aluminum cap is placed on top of the bond pad. This is discussed on pages 2-3 of the instant Specification.

Applicants teach that during the post-passivation manufacturing process of the invention, a second metal layer (such as gold) is formed over the Al cap, and the second metal layer is used for the wirebonding. This invention provides die-size reduction, design flexibility, super reliability for bonded wires, and the possibility of the post-passivation process over aluminum caps, as detailed in the following:

1. This invention makes it possible to perform a wirebonding process over active devices. In the conventional wirebonding process on the aluminum pad, no active devices are allowed under the aluminum pads. In this invention, a second metal layer is formed over the aluminum cap. The second metal layer provides protection during wirebonding for the active devices under the pad. (see pages 8-9 of the Specification). In other words, this invention allows the active devices under the wirebonding pads. The benefits are die-size reduction and design flexibility. Others in the industry did not or would not have discovered these benefits since there would be no reason to add another metal layer (such as gold) over the aluminum cap, prior to wirebonding.

2. Wirebonding is typically used to connect an aluminum pad on a chip to a pad on a circuit board using a gold wire. However, when a gold wire bond directly contacts the aluminum pad, a brittle inter-metallic compound, such as AlAu alloy, may be formed at the interface between the aluminum pad and the wire bond, leading the wire bond to be easily pulled apart from the aluminum pad. Applicants provide a way to solve this problem. In an aspect, Applicants come up with a new wirebonding pad by adding a second metal layer such as a gold layer over the aluminum pad for being wirebonded thereto. (See Fig. 2 and pages 10 and 11 of the Specification). A wire bond can be securely bonded with the second metal layer of the new wirebonding pad. In addition, Applicants further teach there may be a barrier layer (such as TiW) between the second metal layer (such as a gold layer) and the aluminum pad. (See page 10 of the Specification) This prevents the formation of the intermetallic metal, such as an AlAu alloy, from happening. This invention discloses a method of forming a wirebonding

pad with high reliability. Others in the industry did not or would not have discovered this benefit since there would be no reason to add another metal layer (such as gold) over the aluminum cap, prior to wirebonding.

3. When the post-passivation process is performed after the formation of the aluminum cap, the aluminum cap will be damaged by the chemicals used in the post-passivation process. The damaged aluminum cap cannot be used for wirebonding anymore. In this invention, a second metal layer, such as gold, is added to cover the aluminum pad. Since gold is the most chemical-resistive material, the gold pad will not be damaged during the post-passivation process, and can be used for wirebonding. Applicant's invention provides a robust structure which can be used to be wirebonded to, for an aluminum-capped post-passivation interconnection structure. Others in the industry did not or would not have discovered this benefit since there would be no reason to add another metal layer (such as gold) over the aluminum cap, prior to wirebonding.

Reconsideration of the rejection of Claims 69-74 and 80-85 under 35 U.S.C. 103(a) as being unpatentable over Akram (US6,544,880) in view of Yanagida (US6,545,355) is respectfully requested in accordance with the following remarks.

Akram (US6,544,880) teaches a semiconductor die 10 including a bond pad 12. The bond pad comprises a copper metal layer base 12' and one or more additional layers of metal 12'' (col. 4, lines 6-24). Figs. 2B-2D show one additional metal layer 12'' over the copper metal layer base 12', used to be wirebonded thereto (Fig. 2D). Akram lists many materials in col. 4, lines

29-39 that can be used as the metal layer 12'', including gold, silver, palladium, noble metals, nickel, and any of their alloys, but aluminum is not one of the materials disclosed. The metal layer 12'' provides "a good metal to which an effective wire bond may be formed." (col. 5, lines 8-11) Figs. 2E-2F show an additional barrier metal layer 12''' over the copper metal layer base 12' and under the metal layer 12'' to prevent interaction between the two metals (col. 5, lines 36-45). This layer may be tantalum, titanium, or nickel, or their alloys (col. 5, lines 44-54). Akram fails to teach or suggest an aluminum layer over the copper metal layer base 12'.

Yanagida discloses a copper electrode pad 2a, shown in Fig. 1. An adhesion layer 20a of aluminum or titanium is formed on the copper pad. Then, a BLM ((Ball Limiting Metal) layer comprising a bottom layer of Cr or Ti, a second layer of copper, and a third layer of gold is formed on the adhesion layer. A solder ball is formed over the BLM layer (col. 6, lines 4-23). The Examiner says that it would have been obvious "to modify the semiconductor of Akram to include aluminum as disclosed in Yanagida because it aids in providing high durability." However, Yanagida only teaches that aluminum provides durability for solder bumps, not that it provides durability in wirebonding. There is no discussion of wirebonding in Yanagida. Moreover, Yanagida teaches away from the wirebonding. At the time of Yanagida's invention, the industry was in volume production of forming the solder bumps on the aluminum pads. When the IC copper interconnection and pad emerged, Yanagida attempted to take advantage of the mature industry infrastructure of forming solder bumps over aluminum pads by adding an aluminum layer 20a over copper electrode pad 2a.

If a wirebonding process were applied to Yanagida's device, those skilled in the art would likely bond a wirebonded wire to the adhesion layer 20a comprising aluminum, because it is well known in the field that aluminum is capable of being wirebonded thereto. Those skilled in the art would have no motivation to add another metal layer used to be wirebonded thereto over the adhesion layer 20a comprising aluminum. It is believed that the claimed subject matter of a second metal layer used to be wirebonded thereto over a first metal layer comprising aluminum should patentably distinguish over the prior art.

Furthermore, it is noted that while it is agreed that Akram and Yanagida are both in the field of semiconductors, they are non-analogous prior art due to significant differences in structure and function.

Structurally, "flip chip" packaging as described in Yanagida provides a direct electrical connection of face-down (hence, "flipped") electronic components onto substrates, circuit boards, or carriers, by means of conductive bumps on chip bond pads. The conductive bumps can be formed across the whole area of a semiconductor die, accommodating many connections. Attachment pads are metallized to make them more suitable for being soldered onto, and a small dot of solder (in the case of solder bumps as in Yanagida) is then deposited on each of the pads. The chips are then cut out of the wafer.

Wire bonding, on the other hand, uses face-up chips with a wire connection to pads, which are limited to the perimeter of the die. Individual chips are patterned with small pads of metal near their edges.

Functionally, conductive bumps provide a thermally conductive path to carry heat from the chip to the substrate. In addition, the bump provides the mechanical mounting of the die to the substrate. Finally, the bump provides a buffer due to thermal mismatch between the chip and substrate.

Wire bonds, on the other hand, form very little in the way of thermal conduction, nor do they serve much of a mechanical mounting and buffer function - wire bonded chips instead have their back sides mounted to and spaced from underlying carriers by epoxy or other adhesive materials.

A final significant difference between solder bumping and wirebonding is the mechanical stress that results when a wirebonder impacts the semiconductor die. This stress can be quite significant, and is not experienced in forming solder bumps since there is slight mechanical connecting done to form a solder ball - just a deposition and then melting of the solder to form the ball.

Therefore, the two cited references are non-analogous and the teachings of Yanagida are not pertinent to those of Akram.

Reconsideration of the rejection of Claims 69-74 and 80-85 under 35 U.S.C. 103(a) as being unpatentable over Akram (US6,544,880) in view of Yanagida (US6,545,355) is respectfully requested in accordance with the remarks above.

Reconsideration of the rejection of Claims 75 and 86 under 35 U.S.C. 103(a) as being unpatentable over Akram in view of Yanagida and Galloway (US5,783,868) is respectfully requested in accordance with the following remarks.

It is agreed that Galloway's gold layer 12 has a thickness of 3 microns. However, Galloway's gold layer has nothing to do with either Akram's metal layer 12'' or Applicants' second metal layer. Galloway's gold layer 12a, used to be wirebonded thereto for testing purposes, is formed over a passivation layer 18 away from a bond pad 16 exposed by an opening in a passivation layer 18. After the testing is complete, the wire bond 92 and gold layer 12a not over the bond pad 16 are removed (col. 3, lines 51-60). Connections are made to the bond pad 16 through the gold layer 12 and a gold bump 24 (col. 3, lines 25-35). As discussed above, the wirebond 92 for removing the gold layer 12a has a significantly different function from Akram's wirebond for connecting a semiconductor die to an external circuit. Therefore, it is believed that the easily-removed bond pad 12a is non-analogous to the bond pad 12'', 12' and/or 12''' of Akram's device.

Therefore, based on the arguments above, the claimed invention is believed patentable over Akram in view of Yanagida and Galloway.

Reconsideration of the rejection of Claims 75 and 86 under 35 U.S.C. 103(a) as being unpatentable over Akram in view of Yanagida and Galloway (US5,783,868) is respectfully requested in accordance with the remarks above.

Reconsideration of the rejection of Claims 76-78 and 87-89 under 35 U.S.C. 103(a) as being unpatentable over Akram in view of Yanagida and Weng (US6,720,243) is respectfully requested in accordance with the following remarks.

Weng discloses an adhesion layer of chromium or titanium, an overlying barrier layer of titanium tungsten, and an overlying wetting layer of gold or copper. A solder bump is formed over the wetting layer. However, Weng fails to teach, hint or suggest that a pad including multiple metal layers 106, 108 and 110 can be used to be wirebonded thereto, but teaches the pad is used to be solder bonded thereto, which is believed to be non-analogous to the pad 12'', 12' and/or 12''' in Akram's device used to be wirebonded thereto.

Reconsideration of the rejection of Claims 76-78 and 87-89 under 35 U.S.C. 103(a) as being unpatentable over Akram in view of Yanagida and Weng (US6,720,243) is respectfully requested in accordance with the remarks above.

Reconsideration of the rejection of Claims 79 and 90 under 35 U.S.C. 103(a) as being unpatentable over Akram in view of Yanagida and Chikawa et al. (US5,310,699) is respectfully requested in accordance with the following remarks.

Chikawa et al disclose an adhesion/barrier layer of titanium-tungsten over an aluminum electrode and under a gold bump electrode. However, Chikawa fails to teach, hint or suggest that a pad 6 can be used to be wirebonded thereto, but teaches the pad 6 is used to have a gold bump

7 formed thereon, which is believed to be non-analogous to the pad 12'', 12' and/or 12''' in Akram's device used to be wirebonded thereto.

Reconsideration of the rejection of Claims 79 and 90 under 35 U.S.C. 103(a) as being unpatentable over Akram in view of Yanagida and Chikawa et al. (US5,310,699) is respectfully requested in accordance with the remarks above.

All claims are believed to be in condition for allowance and that is so requested..

It is requested that should Examiner Lewis not find that the Claims are now Allowable that she call the undersigned at 845 452-5863 to overcome any problems preventing allowance.

Respectfully submitted,

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